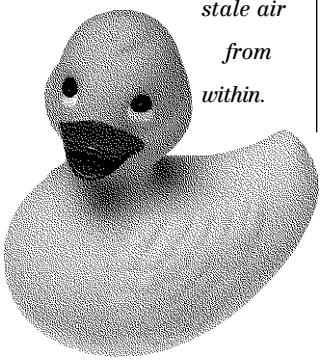
GREEN SEAL'S GREEN Chase REPORT

APRIL 1997

DISCOVER DUCTS

Ducts are an integral part of a home's comfort delivery system, carrying cool air in the summer and heated air in the winter. In homes with active ventilation systems, ducts also deliver fresh outside air and remove stale air from within. When the system works well (that is, when ducts are properly routed, connected, fastened, sealed and insulated), magic happens and the home and its occupants are kept comfortable.

In homes with active ventilation systems, ducts deliver fresh outside air and remove stale air from within.



This delivery system is often an overlooked element in a home's heating, ventilation and air-conditioning (HVAC) installation. Builders and owners who are concerned with added-value may specify energy-efficient appliances such as heat pumps, high-efficiency central air-conditioning systems or forced-air furnaces. Regardless of their efficiency, all of these HVAC appliances rely on properly designed, installed and insulated ducts to deliver their goods. In this report, we review products used to seal and insulate ducts, the benefits of doing so, and recommend environmentally responsible products.

Why you should care

While duct sealing and insulation may seem like an invisible aspect of construction, their effect on a house's comfort and energy consumption can be significant. Badly designed ducts and poor duct work can cause uneven air distribution, inadequate house ventilation or bothersome humidity levels. These conditions result in areas that are too cold or too hot, an increase in dust and other contaminants being circulated, and mold and mildew growth. Appliances must also work harder under these conditions, using more energy.

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Why you should care
Continued from page 1

A recent Florida Solar Energy Center survey found that the average Florida home lost 11% of its heating or cooling energy because of poor duct work. After the researchers repaired and corrected the duct systems in these houses, the annual reduction in heating and cooling bills averaged $110. Nationally, there are almost 50 million American homes with forced-air heating, and every new home built with a forced-air HVAC system requires duct work. Ensuring that these installed duct systems (both supply and return networks) work properly will not only increase owner comfort, it will also save money and reduce the pollution caused by the combustion of fossil fuels, including emission of CO_2, the major greenhouse gas.

Poor duct work has three possible causes. First, the system itself may not be designed for optimal air delivery or return. Second, shoddy workmanship can also contribute to ongoing problems. Components may be haphazardly put together without proper consideration for tightness or system integrity. Third, the components may be put together correctly, but without the right sealing materials.

Fixing the first cause is beyond the scope of this report. The fixes for the second and third can be as simple as attaching, sealing and insulating ducts with more durable and effective materials.

Recommended Sealing Methods

JOINT OR CONNECTION TYPE	SEALING METHOD
Flexduct to collars, sleeves or fittings	adjustable band and foil-backed tape
Metal collar to junction box	mastic
Blower compartments, damper control mechanism doors, or areas where accessibility may be needed	foil-backed tape
Plenum, corners and joints	mastic
Plenums to air handler	mastic
Metal pipe joints	Self tapping sheet metal screws (at least 3) and mastic
Wide gaps (>1/4 in), large joints or round to rectangular transitions	Mastic reinforced with mesh tape

Sealing materials

Building inspectors in several states have routinely found instances where sections of ducts were never installed, connected, or had broken or fallen away completely, leaving gaps in the system. A properly assembled system requires the duct work to be well connected, attached and sealed from the start.

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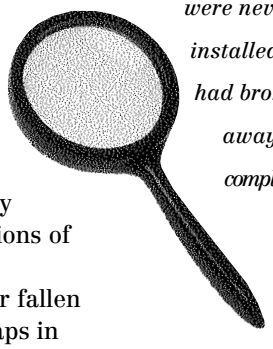

The silver gray cloth tape popularly named “duct tape” may be good for a variety of household applications, but it will peel and crack when exposed to humidity and temperature changes. Because of poor performance, the use of duct tape to seal duct joints and seams is not recommended, and its use has been prohibited in a number of localities’ building codes. Fortunately, there is an alternative high performance sealing system available: mastic.

The term “mastic” is commonly used to describe a number of sealing systems, including some types of adhesive tapes. As used in this report, mastic describes the gooey paste that is the recommended method of sealing duct gaps and seams. A number of manufac-turers have recently introduced foil-backed adhesive tapes that out-perform duct tape in sealing duct joints, seams, and insulation wraps. (See “Tapes,” page 5.)

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Mastic

Mastic is a thick adhesive paste, formulated to dry quickly and durably and to fill gaps in duct work. Designed to be brushed, trowelled, hand wiped (using latex gloves), or extruded onto duct joints and seams, one of its major advantages over other sealants (such as adhesive tape) is its suitability for use on old and new surfaces, for both sheet metal and flexible duct joints. It is sold in tubes or in 1, 2 and 5 gallon tubs, at about $15 to $25 per gallon. One gallon covers roughly 300 linear feet (at 3" width). For wide gaps, it is recommended that mastic be applied over mesh tape for additional reinforcement.

Mastic formulations vary. We found several solvent-based mastics containing petroleum-based components and solvents, such as styrene rubber (SBR) or synthetic rubber resin. There are also a number of water-based mastics with vinyl, acrylic or latex components. Some have longer curing periods and may be more suitable for new construction uses. Others have shorter curing periods, but may contain more solvents.

Mastic Products

GS REC'D	PRODUCT	MADE BY	VOC[a] (g/l)	CURE[b] (hrs)	MSDS HAZARDOUS COMPONENTS[c]	PERFORMANCE CLAIMS[d]	CERT. BY[f]
√	Kingco11-600	King Adhesives	<1.0	12-24	Non Toxic	SMACNA	UL
√	RCD #9	RCD	<1.0	72	Calcium Carbonate*	ASTM E-84	UL
√	Uni-Mastic 181	United McGill	<1.0	48	Non Toxic	SMACNA	UL
√	RCD #6	RCD	<1.0	72	Calcium Carbonate*	ASTM E-84	UL
√	United Duct Sealer	United McGill	1.2	48	Vinyl acetate (0.06%)	SMACNA	UL
√	DS-321	Hardcast	<20	48	Chlorinated paraffin	SMACNA	UL
√	Flex Grip	Hardcast	20	48	Chlorinated paraffin	SMACNA	UL
	RCD #8	RCD	<1.0	72	Titanium dioxide	ASTM E-84	UL
	Eco-EZ Seal	Mon-Eco Ind.	NA	48	Chlorinated paraffin	NFPA	UL
	Eco-Everflex	Mon-Eco Ind.	NA	48	Chlorinated paraffin		
	King Seal	King Adhesives	<20	24-48	Calcium carbonate*	SMACNA	UL
	Metacaulk	Rectorseal	NA	NA	NA		
	Iron Grip	Hardcast	20	48	SBR resin	SMACNA	UL
	Uni-Mastic	United McGill	<1.0	48	N-Butyl Acrylate		

√ Green Buys - recommended products.

NA: not available

[a] VOC levels are in grams per liter as reported by the manufacturer. Green Seal did not test these products for VOC levels. All of the products listed are water-based and can be cleaned up with soap and water.

[b] Typical product curing time in hours, as reported by manufacturers. Curing time is measured at 70 °F and 50% humidity level.

[c] Manufacturers are required to list hazardous components in their products' material safety data sheets (MSDS). The components listed by Green Seal in this column represent the largest component by weight listed in each of the product's MSDS. In some cases, such as RCD's, the product listed is the only component classified as hazardous.

[d] Manufacturers claim that their products meet the specifications listed. SMACNA is the Sheet Metal and Air Conditioning Contractors National Association - SMACNA specifies requirements for duct construction and pressure tests. ASTM-84 is the American Society for Testing and Materials's flame resistance test for materials.

[f] These products also certified by Underwriters Laboratories to meet Standard 181, which covers sealant characteristics, including adhesion, flexibility and thermal resistance.

* This material is usually considered hazardous in an uncontrolled dusting condition. In these formulations, dusting would be very unlikely to occur.

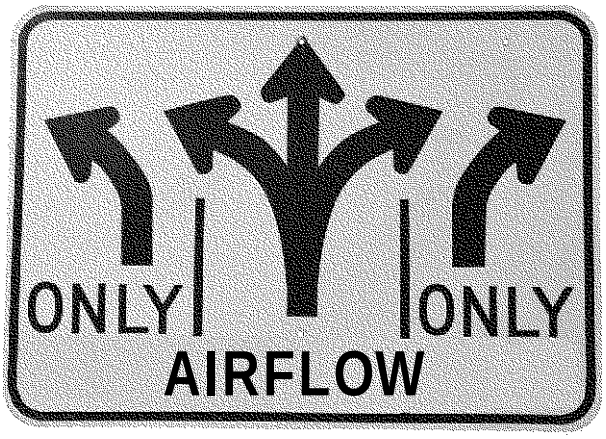
Mastic
Continued from page 3

An industry-sponsored panel is attempting to define mastic performance characteristics such as minimum tightness and drying time, but no standards exist at the present time. We have developed criteria for mastic selection, listed below, based on our survey of existing products. Recommended products are listed in the table "Mastic Products" on page 3. Because the use of mastic is still fairly new, the products listed may not be available widely. We have included manufacturer contact information at the end of this report.

Mastic selection criteria

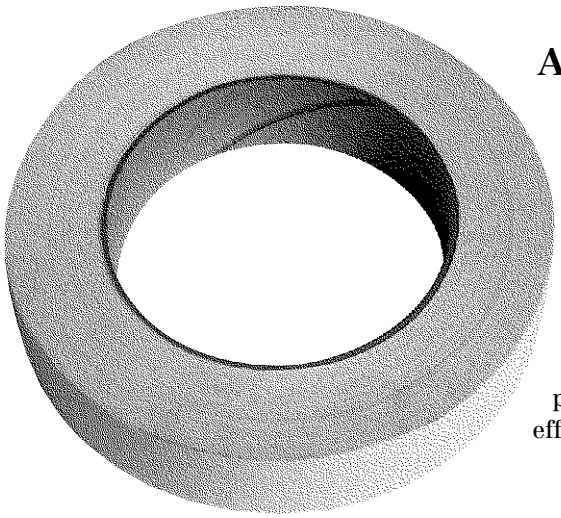
■ **Water-Based Products.** Water-based products do not require harsh chemicals for cleanup, meaning less worker exposure to hazardous chemicals and less chemicals to use and dispose.

■ **Low VOC (volatile organic compounds).** VOCs are released during the curing process (and may continue over the life of the product). Water-based products generally contain less harmful solvents, and are lower in VOC content. Acceptable VOC levels should be about 30 g/l or less.



■ **Non-Toxic Components.** There is a good chance of worker exposure during the application of mastic, especially in the tight confines of a home's crawlspace or attic. A combination of low VOCs and non-toxic components minimize long-term worker health hazards. Manufacturers' material safety data sheets (MSDS) list components and safe handling techniques.

■ **Meet Safety/Fire code.** This rating is an important consideration for duct systems that carry forced-air heating. Many jurisdictions that require mastic for ducts also mandate that the mastic meets flammability requirements. Mastics should meet the requirements of UL-181 or its equivalent. UL-181 specifies tests for air duct materials and connector systems for compliance with the National Fire Protection Association's standards NFPA 90A and 90B.



A New Technology

Researchers at the Lawrence Berkeley National Laboratories have developed and tested a new technology to seal ducts using an aerosol spray. The new technology injects fine particles of a liquid sealant into a duct space, and promises to seal duct systems effectively and economically.

Once a duct system is installed/secured and the larger gaps are sealed, the registers are blocked and a blower is used to distribute the sealing material throughout the system. The sealant attaches to the edges of the leaks and seals them, sometimes in as little as 2 hours. The blower apparatus also allows for system leakage to be measured before and after sealing, thus providing a duct leakage test as well as duct sealing. This technology uses less material per house than currently needed with mastic.

Initial laboratory testing has been completed and researchers in LBNL's Aerosol Sealant Project are refining the technology for commercial use. Their work includes pursuing Underwriter's Laboratories certification, long term tests, large scale field tests of the sealant apparatus, analyzing the cost-effectiveness of duct sealing, and cultivating industry partners for commercialization. For more information, contact Mark Modera of the LBNL Indoor Environment Program at (510) 486-4678; Fax: (510) 486-6658, or MPModera@lbl.gov.

Tapes

A number of adhesive tape products are available for sealing duct joints and seams. Tapes can be more convenient and less messy than mastic. They can reduce worker exposure, require no cleanup afterwards and produce almost no VOCs (Note: almost all adhesive tapes require the cleaning of joint and seam surfaces prior to application). However, they do not seal as tightly as mastic and do not last as long. In some jurisdictions, the use of tapes may not comply with building codes. Additionally, for an experienced installer, mastic is often faster to use than tape.

Foil backed tape can withstand a duct system's heating and cooling cycles and will not deteriorate like duct tape. "UL 181" tape represents a class of foil-backed tape that has undergone additional testing and been listed by Underwriters' Laboratories. Foil backed adhesive tapes are generally available in 100 and 150 ft rolls, at between $15 to $25 per roll. We recommend that the use of tape be limited to areas where accessibility may be needed, such as blower compartments or damper control mechanism doors (see the table on page 2).

We have identified several products based on their reported performance in safety tests, including measured fire-spread potential, smoke production, and the validity of these claims (UL certification). Products are listed below.

Tape Products

PRODUCT	CO	TYPE[A]	THICK[b]	PERF. CLAIM[c]	FLAME INDEX[d]	SMOKE INDEX[e]	CLASS[f]	CERT.[g]
324A Foil Tape	Nashua	foil		BOCA	NA	NA	UL -181	UL
325A Foil Tape	Nashua	foil		BOCA	NA	NA	UL-181	UL
Foil Mastic 360-17	*Polyken*	*Al*	*17*		*5*	*0*	*UL-723*	*UL*
Aluma Grip	Hardcast	Al	32	SMACNA	NA	NA	-	Ind.
Foil Grip	Hardcast	Al	17	SMACNA	10	35	UL-723	UL
487A	Ideal	Al	17	NA	25	50	UL-181	UL
587A	Ideal	Al	NA	NA	25	50	UL-181	UL
490	Ideal	foil	NA	NA	25	50	UL-181	UL
Shurflex Foil SF-682	*Shurtape*	*foil*	*11*	*BOCA*	*5*	*25*	*UL-723*	*UL*
AF-100	Shurtape	Al	14.2	BOCA	5	5	UL-181	UL
Fasson 0810	Avery Dennison	Al	NA	BOCA	NA	NA	UL-181	UL
FasTape 0895	Avery Dennison	Al	7.7	BOCA	20	50	UL-181	UL
1522A Foil Tape	Venture	Al	13.7	SMACNA	20	40	UL-181	UL

Italicized products indicate best flame and smoke indices performances.

[a] Type - Most tapes have a facing of aluminum (Al) or alloy (foil) over a layer of adhesive.

[b] Thickness - Experts recommend that the foil or aluminum layer thickness should be 1.5 to 2.0 mils (1 mil = 0.001 in), and the adhesive layer should be 5 to 7 mils at a minimum.

[c] Performance Claims - Manufacturers make their product according to a number of measures, depending on their market. In the Northeast, BOCA , the Building Officials' Code Association has set guidelines in Section 304 for duct construction. SMACNA, the Sheet Metal Air-conditioning Contractors National Association, has also set guidelines for duct tightness. Products that claim to meet SMACNA guidelines are tested for pressure and leakage resistance.

[d,e] Smoke and Flame Indices - These indices represent the tape's resistance to smoke generation and flame spread under laboratory conditions. The lower the indices, the less likely that a product will generate smoke or catch on fire quickly. Products italicized above indicates best smoke and flame indices performance.

[f] UL-181 indicates that these products have been certified by UL for sealant characteristics, including adhesion, flexibility and thermal resistance. UL-723 refers to products that have been certified for flame conduction and smoke generation characteristics only.

[g] Certification - Products that have been tested by an independent outside laboratory.

Insulation

In a typical home, a number of supply and return ducts are routed through unconditioned spaces such as the attic, basement/ crawlspace, or garage. Because of the temperature extremes in these spaces, even a perfectly sealed duct system will lose energy across the duct surface. This is especially true of a sheet-metal duct system. A number of studies have found that uninsulated ducts can lose about the same amount of energy through conduction as they do through leaks.

To reduce this energy loss, it is recommended that ducts be routed through conditioned spaces where possible, and well insulated in unconditioned spaces. Insulation can be installed by simply wrapping insulation (usually fiberglass insulating sheets) around installed, secured and sealed duct systems, or by using flexible, pre-insulated ducts. In terms of performance and longevity, sealed and insulated metal ducts tend to last much longer than flexible insulated ducts. Poorly suspended ducts, especially flexible ducts, can sag over time, restricting airflow through the system. In addition, the corrugated interior surface of flexible ducts provides significant resistance to air flow.

Metal duct insulation (duct wrap) comes in several thicknesses and R-values, with foil, vinyl or no facing, and can be installed easily and quickly (we recommend using insulation that exceeds the minimum code requirement of R-11). As a rule of thumb, faced insulation should be used where there is a potential for human exposure, such as in the basement and garage. Vinyl faced insulation should be used on ducts carrying air-conditioned air or air from heat pumps. Products with facing need to have a flame spread rating by a safety or code-setting organization, such as UL or its equivalent. We list several insulation manufacturers at the end of this report.

Duct Testing Methods

It may be beneficial to test new homes to ensure that they have an adequate duct network, or that sealing methods are working appropriately. A typical forced-air distribution system's duct network delivers conditioned air from the furnace, heat pump or air-conditioner to the registers in the living space, and air from these areas back to the appliance to be heated or cooled. Ideally, this system is designed to be a pressure-balanced loop, with the same quantity of air leaving and entering the home's conditioned

SUCCESS STORY

A four unit apartment building in West Virginia was measured for energy losses resulting from leaky and uninsulated ducts running through unconditioned spaces. In the upstairs apartments, ducts ran through the unheated attic; in the downstairs apartments, ducts ran through the unheated crawlspace. Two apartments were retrofitted with duct systems run completely through conditioned spaces, using rigid and flexible ducting systems. The other two apartments were left untouched as the control group. All four units were equipped with electric heat pumps and back-up electric resistance heat.

Over the course of one year, the retrofitted apartments used an average of 34% less heating energy and 71% less cooling energy than the control units. The retrofitted units also reduced compressor run time, as well as reduced peak-demand usage (demands during high energy use periods) by 59%. The average indoor temperature of the retrofitted and control apartments varied less than 2 degrees, and occupants of the retrofitted units reported improved comfort.

(from E-source, 1994 *Space Heating Atlas*, reprinted with permission)

zone. Weaknesses in the system in the forms of inadequate ducts, leaks in the system or a combination, will adversely affect the conditioned areas of a home. It is important not only to have the duct system designed and routed properly, but also expertly installed and sealed.

A number of organizations have developed testing methods to determine residential duct tightness, and several utilities have instituted test programs. Homeowners should not test and repair ducts themselves; this should be done only by experts. Most of these methodologies have focused on improving existing systems, but can be applied to new construction in order to test the fitness of new duct systems or new sealing practices.

The three test methods commonly used quantitatively (overall system) to measure leaks at a set test pressure are: blower door subtraction, blower door and flow hood, and "Duct Blaster." The Duct Blaster method is recommended because of its accuracy and the fact that it can be used before drywall installation. Duct sealing with the new aerosol sealing system discussed earlier also provides comprehensive testing results at the same time the ducts are sealed.

Duct Leakage Tests

	BLOWER DOOR SUBTRACTION	BLOWER DOOR & FLOW HOOD	DUCT BLASTER
EQUIPMENT	Blower door	Blower door & flow hood	Duct pressurization & flow device
ADVANTAGES	• inexpensive • good pressure control • measures leakage to envelope	• reliable flow rate • measures leakage to envelope	• inexpensive • good pressure control • accurate measurements • use before drywall installation
DISADVANTAGES	• results are not easily duplicated • not accurate at low pressure • requires large equipment • drywall needs to be in • overemphasizes leaks near registers	• less pressure control • requires 2 pieces of equipment • drywall needs to be in • overemphasizes leaks near registers	• emphasizes leaks near registers

The table above summarizes each method's advantages and disadvantages. Note that all three may not duplicate the exact pressure distribution in the system when the blower fan is operating, which may result in under or over estimation of leakage.

Resources

The Gas Research Institute's publication GRI-96/0304 (773-399-8100) entitled *Final Report: Thermal Distribution Efficiency Program* is an excellent source of information on cost-effective solutions to duct efficiency problems in new residential construction. Contact your local utility for information on duct construction and system testing.

Product Manufacturers

MASTIC

Foster Product Corp. 800-231-9541
Hardcast 800-527-7092
King Adhesives Corp. 800-233 8171
Mon-Eco Industries 800-899 6326
RCD Corp. 800-854 7494
Rectorseal 713-928-6423
United McGill Corp. 800-624-5535

TAPE

Avery-Dennison 216-639-2600
Conpac Industries 800-631-5308
Ideal Tape Co. 800-284-3325
Kendall-Polyken 800-328-4822
Nashua Tape Co. 800-258-1760
Shurtape Technologies 800-438-5779
Venture Tape Corp. 800-343-1076

INSULATION/FLEXDUCT

Airex Limited 416-241-8667
ATCO Rubber Products, Inc. 800-877-3828
CertainTeed Corporation 215-341-7000
Flexible Air Movers 800-456-1326
Hart and Cooley 209-875-1212
JP Lamborn 209-294-7172
RCS (Residential Control Systems) 800-952-2425

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